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EVALUATION OF UNIT 1 COMPUTER

CLASS 1E - NON-CLASS 1E

INTERFACES

DCC15.0-A REV. 1

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EVALUATION OF UNIT 1 COMPUTER CLASS 1E - NONCLASS 1E INTERFACES

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REVISION	DESCRIPTION
1	CHANGED RECOMMENDATION TO CHANGE COMPUTER INPUT CONTACTS FOR HV-B21-1F016, HV-B21-1F019, HV-G33-1F001 AND HV-G33-1F004 TO OPEN CONTACTS WHEN VALVES ARE OPEN INSTEAD OF ADDING ISOLATION DEVICES.

1.0 SCOPE

The purpose of this SEA is to determine the failure modes of the Class 1E - nonClass 1E interface devices used as Unit 1 digital computer inputs and evaluate the affects of these failures on the Class 1E circuits connected to the interface devices. The concern is that the failure of the Class 1E - nonClass 1E interface devices could prevent the Class 1E circuits from meeting their minimum performance requirements.

2.0 CONCLUSIONS AND RECOMMENDATIONS

2.1 CONCLUSIONS

In the Susquehanna SES Unit 1 Performance Monitoring System (Unit 1 computer), three hundred seventy-four (374) digital computer inputs are derived from Class 1E circuits through fifteen (15) specific types of Class 1E devices as listed on page 6 of this SEA.

Analysis of the Class 1E - nonClass 1E interface devices in Appendix B shows that open contacts of all fifteen (15) devices are able to withstand the specified impressed voltage across the contact without causing loss of operability of the devices. In other words, these interface devices will not fail in such a manner as to prevent the Class 1E circuits from meeting their minimum performance requirements if 120V AC or 250V DC is spuriously impressed on the open contacts utilized in the Performance Monitoring System. However, the specified impressed voltages across computer input closed contacts could weld contacts closed if sufficient current flowed for a sufficient duration.

Analysis of Westinghouse circuit breaker auxiliary switches and NAMCO limit switches in Appendix D shows that these contacts will not weld shut for the specified impressed voltage faults in the configuration utilized at Susquehanna SES. Therefore, further investigation of the effects of welded computer input contacts for these devices is not required. This conclusion is based upon an analysis that shows that the conductors connecting these contacts to the computer will melt open before the contacts weld. This type analysis precludes the need to check the protective devices utilized in the circuits.

Analysis of the other Class 1E - nonClass 1E interface devices in Appendix D shows that these devices will meet their minimum performance requirements even if the computer input contact should perhaps weld shut, except for the reactor water cleanup isolation valves HV-G33-1F001 and HV-G33-1F004 and the main steam line drain isolation valves HV-B21-1F016 and HV-B21-1F019. This conclusion is based upon the evaluation of the installed Class 1E - nonClass 1E devices that show:

-- The interface devices change position and meet their minimum performance requirements before the computer contacts are exposed to potential contact welding.

OR

-- The interface devices are in affiliated (associated) circuits and contacts from these devices are not used in Class 1E circuits.

OR

-- The interface devices are mounted in Class 1E equipment but are used for computer, annunciator, and/or indication inputs only.

In the event computer input limit switches for HV-G33-1F001, HV-G33-1F004, HV-B21-1F016 and HV-B21-1F019 weld shut, the limit switch main drive shafts could perhaps break loose internal to the valves causing the valves to jam, thus potentially preventing full closure of the valves. More than likely the welded shut limit switches would cause damage to the limit switch gearing, but would not prevent the subject valves from closing.

2.2 RECOMMENDATION

To assure that the HV-G33-1F001, HV-G33-1F004, HV-B21-1F016 and HV-B21-1F019 valves meet their minimum performance requirements, with impressed voltage faults on their computer input cables, the computer input limit switches should be rewired such that these valves change positions and meet their minimum performance requirements before the computer input switches are exposed to potential welding. The rewired valve limit switches should be normally open and closed only when the valves are 100% closed (i.e. switch closed when the valves closed in the primary containment isolation position.) This action is being tracked by NCR 87-0021. 

In order to preclude the need for future engineering analysis and maintain compliance with Regulatory Guide 1.75, Qualified Electrical Isolators, capable of withstanding 120V AC and 250V DC, should be installed for newly engineered digital computer inputs developed from Class 1E devices. Also Qualified Electrical Isolators should be installed for existing computer inputs when modifications to existing Class 1E - nonClass 1E computer interface devices are performed. This recommendation is in-line with NPE-Electrical Group strategy of eliminating potential pitfalls for maintaining compliance to the plant licensing commitments.

This recommendation will be included in the Design Description Manual, Chapter 29 for the Computer/ACR and E1012, "Specification of Electrical Separation."

3.0 INPUTS AND ASSUMPTIONS

3.1 INPUTS

At Susquehanna SES, all computer input circuits are nonClass 1E. A large number of these inputs are developed from Class 1E devices.

Regulatory Guide 1.75 which endorses IEEE 384-1974 allows the connection of low-energy nonClass 1E circuits to Class 1E devices provided an analysis has been performed to demonstrate that the Class 1E circuits are not degraded below an acceptable level for faults on the nonClass 1E circuits.

Computer cables are routed in nonClass 1E raceways which also contain 120V AC, 125V DC and 250V DC cables. Potential damage to cables in nonClass 1E raceways may cause accidental imposition of 120 volts AC or 250 volts DC on computer input wire(s), and through these wires to the Class 1E device(s).

Both open contacts and closed contacts of the Class 1E - nonClass 1E computer interface devices are to be evaluated.

The total number of the computer points (circuits) requiring evaluation for Class 1E - nonClass 1E interfaces is 1510. These are listed in "Susquehanna Unit 1 I/O Specification Listing - Digital Real", dated 9/06/1989.

The study is limited to digital inputs to the Unit #1 computer.

3.2 ASSUMPTIONS

The study was based on as-built drawings and the documents issued as of the date of task initiation.

Affiliated circuits in this study were treated the same as Class 1E circuits.

A change in state of a computer input contact while there is an impressed voltage was not considered. Only the contact in the open or closed position was analyzed.

4.0 METHOD

All computer inputs listed in the "Susquehanna SES Unit #1 I/O Specification Listing, Digital Real" were examined to identify the system drawings and documents required for detail review.

All of these drawings and documents were reviewed to determine which computer inputs are derived from the safety-related Class 1E devices and which are derived from nonClass 1E devices. The results of this review are listed in the Computer Input Data Table shown in Appendix A. The table also includes the information on related reference drawings, device tag numbers and locations.

The Class 1E devices were sorted to determine identical devices such as relays, limit switches, contactors, etc. Each device rating, type, manufacturer and model number was identified and documented in the Computer Input Data Table.

The function and operation of all Class 1E devices was analyzed in order to evaluate the impact of possible device failure on Class 1E circuits.

Evaluation of the failure modes was performed for each Class 1E device, based on the possibility of accidental imposition of 120V AC or 250V DC on computer input wires. The device contact (output) functions and failure mode analysis for each device is provided in Appendix B.

The references used in the study were compiled and those not presently available in PP&L files are provided in Appendix C.

The Class 1E - nonClass 1E interface devices were reviewed in Appendix D to determine if the contacts from these devices could perhaps weld shut during impressed voltage faults. For the devices with contacts that would not weld shut during faults, no further action is required.

For the Class 1E - nonClass 1E interface devices that may weld shut, evaluations in Appendix D were performed to assure that these devices can perform their safety-related functions with welded computer input contacts.

5.0 RESULTS

Review of the "Susquehanna SES Unit #1 I/O Specification Listing" containing 1510 computer points revealed that the total number of the computer points (circuits) derived from Class 1E devices is 374. Thirty-two (32) of them are derived from Unit #2 Class 1E components.

All computer points, related reference drawings, device tag numbers and locations, device ratings, type, manufacturer and model numbers are listed in Appendix A.

There are fifteen (15) specific type of Class 1E - nonClass 1E computer input interface devices:

1. Westinghouse MOC Auxiliary Switch.
2. Limitorque Limit Switch.
3. NAMCO Limit Switch.

4. GE CR105 Magnetic Contactor.
5. GE HFA51 Relay.
6. GE HMA11 Relay.
7. Cutler-Hammer Reversing Contactor.
8. Cutler-Hammer Type "M" Relay.
9. Agastat EGP Relay.
10. Agastat E7024 Timing Relay.
11. Westinghouse High Speed AR Relay.
12. Magnetrol Model 751 Level Switch.
13. FCI Model 8-66 Liquid Level Controller.
14. GE Range Switch.
15. Potter & Brumfield KH-4690 Relay.

A brief description of each device, including major electrical data and evaluation of the failure modes for each device, is provided in Appendix B.

Computer inputs utilize contacts which are open or closed during normal plant operation. In most computer input circuits, a single contact is used. A few inputs have combination of two or more (up to 28) contacts of the identical or different devices in series, parallel or series-parallel configuration.

In the case of accidental imposition of 120V AC or 250V DC on computer input wires due to possible cable or computer failure, open contacts of all the identified Class 1E - nonClass 1E interface devices can withstand these impressed voltages.

Impressed voltages of 120V AC or 250V DC across closed contacts of the following devices will not cause contacts to weld shut:

-- Westinghouse MOC auxiliary switch.
-- NAMCO limit switch.

Impressed voltages across closed contacts of the other thirteen (13) Class 1E - nonClass 1E interface devices could cause contacts to weld shut if sufficient current flowed for a sufficient duration. However, these Class 1E devices will still meet their minimum performance requirements with the computer input contacts welded shut.

Detailed evaluation of welded contacts for each device is provided in Appendix D.

6.0 REFERENCES

6.1 Standard Handbook for Electrical Engineers - 11th Edition.

6.2 IEEE 279-1971.

6.3 IEEE 384-1974.

6.4 Regulatory Guide 1.75, Rev. 0.

6.5 Susquehanna 1 and 2 Operation and Maintenance Instructions Start-Up Range Neutron Monitoring System GEK 73600A, Nov. 1981.

6.6 See Appendix C for further references.

6.7 Electric Power Research Institute, Power Plant Electrical Reference Series, Volume 4, "Wire and Cable," 1987.

EVALUATION OF CONTACT WELDING

DISCUSSION

The Class 1E - nonClass 1E interface device contacts used for computer inputs could weld shut when the continuous thermal current carrying capability of these contacts are exceeded, causing contact melting due to excessive heat and subsequent contact welding. The current flowing across the contacts which produces the excessive heat could be caused by an impressed voltage due to a hot short of the conductors connected to the contacts and 120V AC, 125V DC or 250V DC sources. Contact welding could occur if the circuit is not opened by protective device operation or conductor melting before the contacts melt. The digital computer inputs are connected to the Class 1E - nonClass 1E interface devices through shielded, 2 conductor #16 AWG copper cables, rated at 11 amperes continuous.

The only Class 1E - nonClass 1E interface devices used for computer input that have a continuous thermal current-carrying capability similar to the computer cables are:

-- Westinghouse MOC auxiliary switches.
-- NAMCO limit switches.

These devices will be analyzed to determine if their contacts can weld shut during impressed voltage faults on the computer input cables.

The other Class 1E - nonClass 1E interface devices, listed on page 6 of this SEA, have contacts with continuous thermal current-carrying capability lower than the computer cables. Therefore, it can be concluded that these contacts can perhaps weld shut for impressed voltage faults.

MELT CURRENT-TIME EVALUATION

The Westinghouse MOC auxiliary switches and NAMCO limit switches are constructed using silver contacts with a cross-sectional area of 0.049 square inches (62,500 cir. mils.). The cross-sectional area of #16 AWG. copper is 2,580 cir. mils.

The contact area was calculated using the actual measured contact diameter of 1/4 inch.

The melting current-time for the copper conductor and the silver contacts can be calculated by using I. M. Onderdonk equation (Reference 6.7):

$$\frac{I}{A}^2 t = (0.0297) \log \frac{T_2 + 234}{T_1 + 234}$$

I = Current in amperes.
A = Area in circular mils.
t = Time current applied in seconds.
Tm = Melting point of material in degrees Celsius.
T_1 = Ambient temperature in degrees Celsius.
T_2 = 1083°C for copper.
T_2 = 962°C for silver.
T_1 = 40° C.

The current through the computer input cable and contact are the same for impressed voltage faults. Since the contact mating area could be reduced by a-spotting, misalignment, scratches, contamination, etc., the silver contact area could be reduced to an estimated 25% of 62,500 cir. mils. Using this reduced area and the current relationship in the above equation, a comparison of the time to melt the silver contacts and the copper conductors shows that the melting time of the silver contacts is approximately 34 times greater than the melting time of copper conductor. This time difference is further reduced by 46% because less heat is required to melt silver contacts than copper. This results in the melting time of silver contacts being approximately 18 times greater than the melting time of the copper conductor.

From the above discussion, it is concluded that the #16 AWG. copper conductors connecting the Westinghouse auxiliary switches and NAMCO limit switches to the computer melt open before the contacts weld shut during impressed voltage faults.

CLASS 1E - NONCLASS 1E INTERFACE EVALUATION

GE TYPE CR105, GE TYPE HFA, GE TYPE HMA, AGASTAT TYPE E7024, AGASTAT TYPE EGP, POTTER & BRUMFIELD TYPE KH-4690

The actuating coils for the subject devices are continuously energized, during normal plant operations, with open contacts providing the computer inputs. For the computer contacts to close and be exposed to potential welding, the subject Class 1E - nonClass 1E devices have to de-energize and change the state of their contacts. Once these contacts change state the subject device have met their minimum performance requirements. Therefore, the subject Class 1E - nonClass 1E interface devices meet their minimum performance requirements before the computer input contacts are exposed to potential welding . Note: The installed GE Type HMA and Potter & Brumfield relays used for computer inputs do not perform any safety-related functions.

CUTLER-HAMMER CONTRACTOR AND TYPE M RELAY, WESTINGHOUSE TYPE AR RELAY

The subject devices are installed in affiliated (associated) circuits. These circuits are powered from Class 1E sources. However, these devices are not used in Class 1E circuits. Therefore, welding a computer input contact shut does not effect any Class 1E circuit. By definition, contacts from these devices cannot be used in Class 1E circuits since they are not necessarily nuclear qualified devices.

LEVEL SWITCHES

The FCI and Magnetrol level switches LSH01103E (Diesel Generator E flooding) and LSHC12-1N013 (scram discharge volume high level) are classified as Class 1E because they are mounted in Class 1E equipment. All outputs are used for computer and annunciator inputs. Therefore, welded computer input contacts do not effect Class 1E circuits.

GE IRM RANGE SWITCH

The manually operated IRM range switches are provided to select ten linear ranges for neutron flux measurements in each IRM string during plant start-up. These switches are used only for plant start-up. These switches provide contacts to the IRM trip logic and to the computer. The trip logic circuits develop a trip signal when the monitored neutron flux is above or below the trip unit setpoints. In the event the IRM range switch computer input contact welds shut, a trip output signal could occur if the switch position could not be changed and the neutron flux reached the trip unit setpoint. However, the welded contact would not prevent a trip output signal. Therefore, welded computer input contacts do not effect these circuits from meeting their minimum performance requirements.

LIMITORQUE LIMIT SWITCHES

The Class 1E Limitorque limit switches that provide computer inputs are part of motor-operated valves which are in one of the following groups:

1. Affiliated.
2. Require no automatic operation.
3. Require automatic closure.

The affiliated motor-operated valves, listed in Table 1, are powered from Class 1E sources. However, these valves and their limit switches are not used in Class 1E circuits. Therefore, welding a computer input limit switch does not effect Class 1E circuits.

The Class 1E motor-operated valves which require no automatic operation are listed in Table 2. These valves have open limit switches for computer inputs during normal plant line-up. These limit switches are not exposed to potential welding. In the event the normal plant line-up is changed, the valves change to their new positions before the computer input limit switches are exposed to potential welding. Therefore, welding of the computer input limit switches does not prevent the motor-operated valves from meeting their minimum performance requirements.

[illegible]

The ESW Diesel "E" Cooler Supply Valves Nos. HV-01110E and HV-01120E are required to automatically close for certain DBA's when the Diesel Generator "E" is not aligned and is being tested. For this condition, the computer input limit switches are open and are not exposed to potential welding. If these valves receive an automatic close signal, the valve changes position before the computer input limit switches are exposed to potential welding. Therefore, the welding of these computer input limit switches does not prevent HV-01110E and HV-01120E from meeting their minimum performance requirements.

The Reactor Water Cleanup Isolation Valves Nos. HV-G33-1F001 and HV-G33-1F004 and the Main Steam Line Drain Isolation Valves Nos. HV-B21-1F016 and HV-B21-1F019 are required to automatically close for certain DBA's. However, the computer input limit switches from these valves are closed when these valves are open. In the event the computer input limit switches weld shut, the limit switch main drive shafts could perhaps break loose internal to the valves causing the valves to jam, thus potentially preventing full closure of the valves. Per Dan Warsing of Limitorque Corp., this is very unlikely. More than likely, the welded shut limit switch will cause damage to the limit switch gearing, but will not prevent the valves from closing.

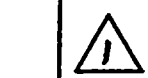
To assure that the HV-G33-1F001, HV-G33-1F004, HV-B21-1F016 and HV-B21-1F019 valves meet their minimum performance requirements, with impressed voltage faults on their computer input cables. The computer input limit switches should be rewired such that these valves change positions and meet their minimum performance requirements before the computer input switches are exposed to potential welding. The rewired valve limit switches should be normally open and closed only when the valves are 100% closed (i.e. switch closed when the valves closed in the primary containments isolation positions). 

TABLE 1

AFFILIATED MOTOR-OPERATED VALVES

HV-B21-1F001	HV-B31-1F023A	HV-B31-1F031B
HV-B21-1F002	HV-B31-1F023B	HV-B31-1F032A
HV-B21-1F005	HV-B31-1F031A	HV-B31-1F032B

TABLE 2

MOTOR-OPERATED VALVES
NO AUTOMATIC OPERATION

HV-01112A	HV-01122A	HV-01112E
HV-01112B	HV-01122B	HV-01122E
HV-01112C	HV-01122C	HV-B21-1F020
HV-01112D	HV-01122D	HV-B21-1F032A
HV-01110A	HV-01120A	HV-B21-1F032B
HV-01110B	HV-01120B	HV-G33-1F042
HV-01110C	HV-01120C	HV-G33-1F104
HV-01110D	HV-01120D	HV-14182A
		HV-14182B